1 INTRODUCTION TO COGNITIVE DEVELOPMENT

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GOALS OF COGNITIVE DEVELOPMENTALISTS

No one can remember what 4-year-old Jason did to get his father so upset, but whatever it was, his father wanted no more of it.

"Jason, I want you to go over to that corner and just *think* about this for a while," his father yelled.

Instead of following his father's orders, Jason stood where he was, not defiantly, but with a confused look and quivering lips, as if he were trying to say something but was afraid to.

"What's the matter now?" his father asked, his irritation showing.

"But Daddy," Jason said, "I don't know *how* to think."

Jason did know how to think, of course. He just didn't know that he did. In fact, Jason had been "thinking" all his life, although in a very different way when he was an infant, and his current thinking was nothing like the mental gymnastics he'd be capable of in just a few years.

Intelligence is our species's most important tool for survival. Evolution has provided other animals with great speed, coats of fur, camouflage, or antlers to help them adapt to challenging and often changing environments. Human evolution has been different. It has provided us with powers of discovery and invention by which we change the environment or develop techniques for coping with environments we cannot change. Although we are not the only thinkers in the animal kingdom, no other species has our powers of intellect. How we think and the technological and cultural innovations afforded by our intellect separate us from all other animals.

This remarkable intelligence does not arise fully formed in the infant, however. We require substantial experience to master the cognitive feats that typify adult thinking, and we spend the better part of two decades developing an adult nervous system. Little in the way of complex thought patterns is built into the human brain, ready to go at birth, although biology obviously predisposes us to develop the ability for complex thought. Our mental prowess develops gradually over childhood, changing in quantity and quality as it does.

In this first chapter, I introduce the topic of *cognitive development*—how thinking changes over time. In addition to describing developmental differences in cognition, scientists who study children's thinking are also concerned with the mechanisms that underlie cognition and its development. How do biological (genetic) factors interact with experiences in the physical and social world to yield a particular pattern of development? How do children of different ages represent their world? Does a 3-year-old understand the world in much the same way as a 10-year-old, or are these children qualitatively different thinkers? Once a pattern of intellectual competence is established, does it remain stable over time? Will the bright preschooler become the gifted teenager, or is it pointless to make predictions about adult intelligence from our observations of children? These and other issues are introduced in this chapter, but they are not answered until later in the book. Before delving too deeply into these issues, however, I need to define some basic terms (see Table 1.1). These definitions are followed by a look at some issues that define the field of cognitive development and have been the focus of controversy during the last century.

TABLE 1.1 ■ Basic concepts in cognitive development.

Cognition
The processes or faculties by which knowledge is acquired and manipulated. Cognition is usually thought of as being mental. That is, cognition is a reflection of a mind. It is not directly observable but must be inferred.
Development
Changes in structure or function over time. Structure refers to some substrate of the organism, such as nervous tissue, muscle, or limbs, or—in cognitive psychology—the mental knowledge that underlies intelligence. Function denotes actions related to a structure and can include actions external to the structure being studied, such as neurochemical or hormonal secretions and other exogenous factors that can best be described as "experience"—that is, external sources of stimulation. Development is characteristic of the species and has its basis in biology. Its general course, therefore, is relatively predictable. Development progresses as a result of a bidirectional, or reciprocal, relationship between structure and function and can be expressed as structure ↔ function.
Developmental function
The species-typical form that cognition takes over time.
Individual differences
Differences in patterns of intellectual aptitudes among people of a given age.

BASIC CONCEPTS IN COGNITIVE DEVELOPMENT

Cognition

Cognition refers to the processes or faculties by which knowledge is acquired and manipulated. Cognition is usually thought of as being mental, although it is instantiated in the brain. That is, cognition is a reflection of a mind. It is not directly observable. We cannot see the process whereby an 8-month-old discovers that a Mickey Mouse doll continues to exist even though it is hidden under a blanket out of her sight, nor can we directly assess the steps a 7-year-old takes to compute the answer to the problem 15 - 9 = ?. Although we cannot see or directly measure what underlies children's performance on these and other tasks, we can infer what is going on in their heads by assessing certain aspects of their behavior. That is, cognition is never measured directly. It is inferred from the behaviors we can observe.

What psychologists can observe and quantify are things such as the number of words children remember from a list of 20, the number of seconds it takes to identify well-known pictures or words, or the amount of time a 6-month-old spends looking at a picture of a familiar face relative to that of an unfamiliar one. For the most part, cognitive developmental psychologists are not really interested in these overt, countable behaviors; what they *are* interested in are the processes or skills that underlie them. What mental operations does a 6-year-old engage in that are different from those performed by a 3-year-old or a 9-year-old? How does speed in identifying words reflect how information is stored in the minds of children of different ages? What kind of mental picture has the infant formed of the familiar face of his mother that allows him to tell her face apart from all other faces? How are such mental pictures created? How are they modified?

This is not to say that cognitive psychologists are unconcerned with socially important phenomena, such as reading, mathematics, or communicating effectively; many are, and they have developed research programs aimed at improving these and other intellectual skills so critical for children's success in a high-tech society. But, for the most part, the behaviors themselves are seen as secondary. What is important and what needs to be understood are the mechanisms that underlie performance. By discovering the mental factors that govern intelligent behavior, we can better understand behavior and its development, which in turn can help us better understand children and foster their development.

Cognition includes not only our conscious and deliberate attempts at solving problems but also the unconscious and nondeliberate processes involved in routine daily tasks. We are not aware of the mental activity that occurs when we recognize a familiar tune on the radio or even when we read the back of a cereal box. Yet much in the way of cognitive processing is happening during these tasks. For most of us, reading has become nearly automatic. We can't drive by a billboard without reading it. It is something we just do without giving it any "thought." But the processes involved in reading are complex, even in the well-practiced adult.

Cognition involves mental activity of all types, including activity geared toward acquiring, understanding, and modifying information. Cognition includes such activities as developing a plan for solving a problem, executing that plan, evaluating the success of the plan, and making modifications as needed. These can be thought of as higher-order processes of cognition, which are often available to consciousness (that is, we are aware that we're doing them). Cognition also involves the initial detection, perception, and encoding of a sensory stimulus (that is, deciding how to define a physical stimulus so it can be thought about) and the classification of what kind of thing it is ("Is this a letter, a word, or a picture of something familiar?"). These can be thought of as basic processes of cognition, which occur outside of consciousness (we experience the product but are generally unaware of the process).

Cognition, then, reflects knowledge and what one does with it, and the main point of this book is that cognition develops.

Development

Change Over Time

At its most basic, **development (or ontogeny)** refers to changes in structure or function over time within an individual. **Structure** refers to some substrate of the organism, such as nervous tissue, muscle, or limbs, or—in cognitive psychology—the mental knowledge that underlies intelligence. When speaking of cognitive development, we use *structure* to mean some hypothetical mental construct, faculty, or ability that frames knowledge and changes with age. For example, children's knowledge of terms such as *dog*, *lion*, and *zebra* could be construed as existing in some sort of mental structure (think of it as a mental dictionary), with the meanings of these words changing over time. Or we could hypothesize some form of mental organization that permits children to place objects in serial arrays according to height, shortest to tallest.

In contrast to structure, **function** denotes actions related to a structure. These include actions external to the structure being studied, such as neurochemical or hormonal secretions, and other factors external to the individual that can best be described as "experience"—that is, external sources of stimulation. Function can also be internal to the structure itself—for example, the exercise of a muscle, the firing of a nerve cell, or the activation of a cognitive process, such as retrieving from memory the name of your first-grade teacher or computing the answer to the problem 26 + 17 = ?. With respect to cognitive development, function refers to some action by the child, such as retrieving the definition of a word from memory, making comparisons between two stimuli, or adding two numbers to arrive at a third.

Development is characteristic of the species and has its basis in biology. Its general course, therefore, is relatively predictable. By viewing development as a biological concept that is generally predictable across all members of the species, I do not mean to imply that experience and culture do not also play a role in development. During the last several decades, developmental psychologists have become increasingly aware that a child's development cannot be described or understood outside of the context in which it occurs, and I address this issue later in this and other chapters, especially Chapter 3.

Structure, Function, and Development

Development is usually conceived as a bidirectional, or reciprocal, relationship between structure and function, in which the activity of the structure itself and stimulation from the environment can contribute to changes in the structure, which in turn contribute to changes in how that structure operates. Function does more than just maintain a structure (that is, prevent it from wasting away); function is necessary for proper development to occur. Function is limited, of course, to the actions that structures are capable of performing. This bidirectional relationship between structure and function can be expressed as structure ↔ function.

The **bidirectionality of structure and function (or structure ↔ function)** can perhaps be most easily illustrated with work in embryology. Chick embryos, for example, display spontaneous movement before muscle and skeletal development is complete. Such movement obviously stems from the maturation of the underlying structures—in this case, bones, muscle, and nervous tissue. When embryonic chicks are given a drug to temporarily paralyze them for as little as 1 to 2 days, deformations of the joints of the legs, toes, and neck develop, which in turn affect the subsequent movement of the limbs (Drachman & Coulombre, 1962). The spontaneous activity of moving the legs provides critical feedback to the genes, which in normal circumstances leads to a properly developed skeleton (Müller, 2003). In other words, the spontaneous activity (function) of the skeletal structures is necessary for the proper development and functioning of the joints (structure). Development proceeds as a result of the interaction of genes with events and agents external to the genes, including functioning of the body itself, all in feedback loops that, when all goes right, produce a species-typical body.

Let me provide an example of the bidirectional relationship between structure and function at the behavioral level. Individual differences in activity level are found in newborns and are believed to be biologically based (Phillips et al., 1978). A highly active toddler will make it difficult for her parents to confine her to a playpen, resulting in a child who has a greater number of experiences outside of her playpen than a less-active child has. These experiences will presumably affect the child's developing intellect (structure), which in turn will affect that child's actions (function). Thus, inherent characteristics of the child (biological structures) influence her behavior, the experiences she has, and the reactions of others to her—all of which influence the development of the child's underlying cognitive/behavioral structures, and so on.

The *functioning* of mental structures promotes changes in the structures themselves. This view is most clearly reflected in the work of Swiss psychologist Jean Piaget. He believed that the activity of the child (or of the child's cognitive structures) is a necessary condition for development to occur. That is, for structures to change, they must be active. The structure's contact with the external world is responsible, to a large extent, for its development. Such a viewpoint makes children important contributors to their own development. Intellectual growth is the result of an active interaction between acting and thinking children and their world, not simply the environment shaping children's intellect or genes dictating a particular level of cognitive ability. (More is said of Piaget's theory throughout this book, especially in Chapter 5.)

I think it is fair to say that all developmental psychologists agree there is a reciprocal, bidirectional influence between structures (be they physical, such as neurons, or abstract, such as cognitive structures) and the activity of those structures (that is, the child's behavior or the firing of neurons). There is still much room for debate concerning *how* various subsystems of the child (neuronal, behavioral, social) interact to produce development, but developmental psychologists agree that development must be viewed as a two-way street. Development is *not* simply the result of the unfolding of genetic sequences unperturbed by variations in environment (structure → function), nor is it the product of "experience" on an infinitely pliable child (function → structure). The concept of the bidirectionality of structure and function is central to developmental psychology and is a theme throughout this book. A more in-depth discussion of bidirectional models of development, along with more examples, is provided later in this chapter and in Chapter 2 during a discussion of the *developmental systems approach*.

Developmental Function and Individual Differences

I will examine two aspects of cognitive development in this book: **developmental function**, or cognitive development, and **individual differences**. In the present context, developmental function refers to the form that cognition takes over time—to age-related differences in thinking. What are the mental abilities of infants? What is a 2-year-old's understanding of numbers, words, and family relations? What about that of a 4- or 6-year-old? How do school-age children and adolescents conceptualize cause and effect? How do they evaluate the relative worth of two products in the grocery store? People concerned with developmental function are usually interested in universals—what is generally true about the course and causes of development for all members of the species. Assessments of developmental function, then, are typically based on averages, with individual variations among children being seen as irrelevant. I should note that most research in cognitive development has been done on children from what have been called **WEIRD cultures** (Western, Educated, Industrialized, Rich, Democratic) (Amir & McAuliffe, 2020; Henrich et al., 2010; Nielsen et al., 2017), making claims of universality suspect.

Developmental scientists are becoming increasingly aware of this problem, and throughout this book I will provide research evidence from both WEIRD and non-WEIRD cultures whenever possible

We all know that at some level, however, variation in development *is* important. Our impressive intellectual skills are not uniform among members of the species. Some people at every age make decisions more quickly, perceive relations among events more keenly, or think more deeply than others. How can these differences best be described and conceptualized? What is the nature of these differences? Once differences have been established, to what extent can they be modified? Will differences observed in infancy and early childhood remain stable, or are some intellectual differences limited to a particular time during development?

Individual differences have developmental histories, making the relationship between developmental function and individual differences a dynamic one. That is, individual differences do not simply constitute genetic or "innate" characteristics of a child. They emerge as children develop, often showing different manifestations at different times in development. Several chapters in this book are devoted exclusively to examining individual differences. In other chapters, individual differences in cognitive abilities are discussed in conjunction with the developmental function of those same abilities.

The Adaptive Value of Cognitive Immaturity

We usually think of development as something progressive—going from simple to more complex structures or behaviors, with children getting "better" or more "complete" over time. This is a wholly reasonable point of view, but such a perspective can cause us to interpret early or immature forms of cognition as merely less effective and incomplete versions of the adult model. Although this might generally be true, it is not always the case. Early or immature forms of development can serve some function of their own, adapting infants or young children to their particular environment (Oppenheim, 1981). For example, young infants' relatively poor perceptual abilities protect their nervous systems from sensory overload (Turkewitz & Kenny, 1982); preschool children's tendencies to overestimate their physical and cognitive skills causes them to persist (and, thus, to improve) at difficult tasks (Shin et al., 2007); and infants' slow information processing seems to prevent them from establishing intellectual habits early in life that would be detrimental later on, when their life conditions are considerably different (Bjorklund & Green, 1992). The point I want to make here is that infants' and young children's cognitive and perceptual abilities might, in fact, be well suited for their particular time in life rather than incomplete versions of the more sophisticated abilities they will one day possess (Bjorklund, 1997, 2007b, 2021). In other words, what adults often consider to be immature and ineffective styles of thought might sometimes have an adaptive value for the young child at that particular point in development and should not be viewed solely as "deficiencies." Children's immature cognition can be seen as having an integrity and, possibly, a function of its own rather than being seen only as something that must be overcome. Such a perspective can have important consequences not only for how we view development but also for education and remediation.

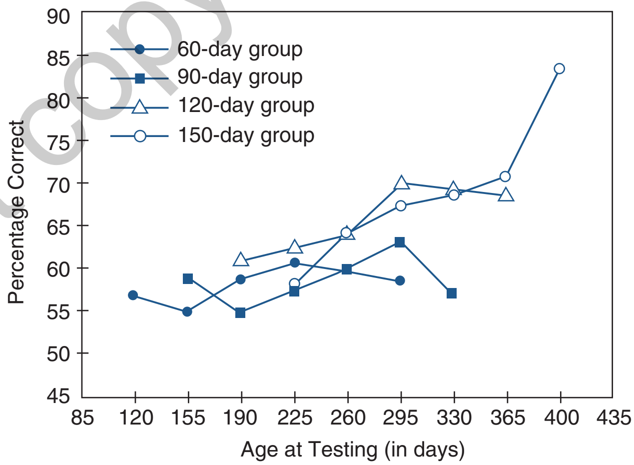
Play

Take *play* for example. Playing is what children do, and by definition is something engaged in voluntarily for no purpose other than its own activity. Although the play of children may have no immediate purpose other than its own enjoyment, it seems to have an important function in development. Play is universal, following a species-typical course in children from diverse cultures, causing Paul Harris (1989) to assert that "the stable timing of [play's] onset in different cultures strongly suggests a neuropsychological timetable and a biological basis" (p. 256), making it an excellent candidate for a feature that has evolved to serve an adaptive function, much as infant-mother attachment or language have. It is through play and observation (rather than via teaching) that children in traditional cultures acquire the skills necessary for survival (Lancy, 2015), and Mark Nielsen (2012) has proposed that counterfactual thinking, which is central to children's pretend play, fosters the development of "a capacity to generate and reason with novel suppositions and imaginary scenarios, and in so doing [children] may get to practice the creative process that underpins innovation in adulthood" (p. 176). I will examine the function of this ubiquitous feature of childhood in several chapters in this book, noting how the various types of play influence the acquisition of important cognitive abilities, including counterfactual thinking, executive function, and tool use, among others.

Too Early Learning

For another example of the adaptive benefit of cognitive immaturity, consider learning. Learning is good, of course, but is early learning always beneficial? Might providing an infant with too

FIGURE 1.1 ■ Discrimination Learning Set Performance for Monkeys as a Function of Age at Which Testing Was Begun.



Source: Adapted using data from H. Harlow (1959, December). The development of learning in the Rhesus monkey. *American Scientist*, 459–479.

much stimulation or learning tasks too soon in development have a negative effect? There is little research on this issue. In one study, Harry Harlow (1959) began giving infant monkeys training on a discrimination-learning task at different ages, ranging from 60 to 366 days. For example, monkeys were to choose which of several stimuli that varied in several dimensions (size, shape, color, and so on) was associated with a reward. Beginning at 120 days of age, monkeys were given a more complicated learning task. Monkeys' performance on these more complicated problems is shown in Figure 1.1 as a function of the age at which they began training. Chance performance for these problems was 50%. As can be seen, monkeys who began training early in life (at 60 and 90 days) seldom solved more than 60% of the problems and soon fell behind the monkeys who began training later (at 120 and 150 days of age). That is, despite having more experience with the problems, the early-trained monkeys performed more poorly than the later-trained monkeys. Harlow (1959) concluded, "There is a tendency to think of learning or training as intrinsically good and necessarily valuable to the organism. It is entirely possible, however, that training can be either helpful or harmful, depending upon the nature of the training and the organism's stage of development" (p. 472).

Might this relate to our species as well? In one of the few such experiments with humans, Hanus Papousek (1977) conditioned infants to turn their heads to a buzzer or a bell. Training began either at birth or at 31 or 44 days of age. Infants who began training at birth took many more trials (814) and days (128) before they learned the task than did infants who began later (278 and 224 trials and 71 and 72 days for the 31- and 44-day-old infants, respectively), causing Papousek to write that "beginning too early with difficult learning tasks, at a time when the organism is not able to master them, results in prolongation of the learning process."

Infants need stimulation—interesting objects and, especially, responsive people to speak to and interact with. However, if stimulation is excessive, it can distract infants and young children from other tasks and may replace activities, such as social interaction, that are vital to their development. I am in no way advocating a "hands-off" policy on educating infants and young children. Rather, I am advocating a recognition that infants' limited cognitive abilities may afford them some benefits. I'll have more to say about "educating" infants in Chapter 11 where I discuss the pros and cons of educational DVDs and videos for babies.

The Benefits of Thinking You're Better Than You Are

The potential benefits of immature cognition are not limited to infancy but can also be found later in life. For example, preschool children think that they can remember more items, communicate more effectively, perform tasks better, imitate a model more accurately, and perform a host of tasks better than they actually can (Bjorklund et al., 1993; Lipko et al., 2009; see Muenks et al., 2018, for a review). Let me provide a specific example from my childhood:

> The first grade class was getting fidgety. There were a few minutes left before the bell rang, so the teacher decided to fill the time with some entertainment. "Can anyone sing a song for us?" she asked, and several children gave renditions of their favorite tunes. "Can anyone dance?" she asked. I felt that this was my time to shine. "I can tap dance!" I answered. I walked to the front of the room and proceeded to shuffle my feet, trying my best to imitate the dancers I had seen on TV. Well, the result *was* entertainment, but

> strictly comedy. My classmates roared with laughter and even the teacher was unable to hide her amusement. Fortunately, the bell rang soon and the children lined up to go home, so my stint in the spotlight was short lived. (Bjorklund, 2007b, p. 111)

My false belief in my dancing ability is not uncommon, and although this particular event led to some embarrassment without any obvious benefit (other than having a story to tell many years later), young children's beliefs that they know more than they actually do, and that they can do more than they actually can, provide them with positive perceptions of their own skills, or a positive sense of **self-efficacy**. Bandura (1997) defined self-efficacy as the extent to which a person views themselves as an effective individual. Self-efficacy develops through experience. Children evaluate the effectiveness of their own actions, compare it with the actions of others, and are told by others how their behavior meets certain standards. Children who believe they are competent (even if they are not) develop feelings of positive self-efficacy. Conversely, when self-efficacy is poor, people tend to behave ineffectually, regardless of their actual abilities.

By overestimating their abilities, children might be encouraged to attempt things that they would not try if they had a more realistic idea of their abilities. In other words, their cognitive immaturity, as reflected by their unrealistic assessments of their abilities, can actually facilitate development rather than hinder it (Bjorklund & Green, 1992). For example, research has shown that 8- to 11-year-old children who overestimated their capabilities had better school performance than did less optimistic children (Lopez et al., 1998). These children may not have been quite as good as they thought, but their school performance was better than that of their more accurate peers. In other research, kindergarten, first-grade, and third-grade children who overestimated their memory abilities showed greater subsequent improvement on memory tasks than more accurate children (Shin et al., 2007). Young children also believe that physical and psychological traits tend to improve over time and that people have substantial control in changing traits, a phenomenon called *protective optimism* (Lockhart et al., 2002, 2017). Being overconfident in one's abilities is mostly limited to preschool-age children. Beginning around first or second grade, children who overestimate their abilities are often at a learning disadvantage (van Loon et al., 2017).

Children's overly optimistic appraisal of their abilities also poses some problems, however. For example, Jodie Plumert (1995; Plumert & Schwebel, 1997) reported that 6-year-olds who consistently overestimate their physical abilities were more accident-prone than less optimistic children were. In other research, Plumert and her colleagues (Plumert et al., 2004, 2007) asked 10- and 12-year-old children and adults to determine when it was safe to ride their bikes across a busy street. (They did not actually cross streets. Judgments were made on a virtual street.) Plumert and her colleagues reported that the children were less accurate in making safety judgments than the adults. Children took longer to get moving, so the gap between cars that they judged to be safe resulted in more close calls than when adults made judgments.

What is the origin of young children's tendency for overestimation? It does not seem to stem from a general cognitive deficit in evaluating performance. For instance, Deborah Stipek (Stipek, 1984; Stipek & Daniels, 1988) noted that young children can make relatively accurate predictions of how other children are likely to perform on school-like tasks but are overly optimistic in predicting their own future performance. Stipek suggested that this overly optimistic self-perception is the result of **wishful thinking**: Children wish for As on their report cards; therefore, they expect As. By the third or fourth grade, however, children's assessments of their own abilities move closer to reality, and they are able to tell the difference between what they wish would happen and what they can reasonably expect to happen (Wente et al., 2020). This is a reflection of children's improving *metacognition* (knowledge about their own thinking), discussed in Chapter 6. Stipek believes that this tendency to overestimate one's own abilities enhances children's self-efficacy and gives them the confidence to attempt things they would not otherwise try. Stipek (1984) proposed that rather than trying to make young children's self-assessments more accurate, we should "try harder to design educational environments which maintain their optimism and eagerness" (p. 53).

We do not totally lose an unrealistic evaluation of ourselves as we age. For instance, adults consistently believe they are better-than-average at most things than an objective assessment would indicate (Zell et al., 2020). However, few well-functioning adults display positive opinions of themselves to the same great extent as the average 4- or 5-year-old.

SECTION REVIEW

Cognitive development involves changes in children's knowledge and thinking over time.

Cognition

- *Cognition* refers to the processes or faculties by which knowledge is acquired and manipulated.
- Cognition reflects knowledge and what one does with it, and cognition develops.

Development

- *Development* (or *ontogeny*) refers to changes in structure or function over time within an individual.
- *Structure* refers to some substrate of the organism, such as nervous tissue, muscle, or limbs, or—in cognitive psychology—the mental knowledge that underlies intelligence.
- *Function* denotes actions related to a structure, including actions external to the structure being studied, such as neurochemical or hormonal secretions, and other factors external to the individual that can best be described as "experience."
- The *bidirectionality of structure and function* (or structure ↔ function) refers to the bidirectional, or reciprocal, relationship between structure and function, in which the activity of the structure itself and stimulation from the environment contributes to changes in the structure, which in turn contribute to changes in how that structure operates.
- *Developmental function* refers to the form that cognition takes over time (that is, to age-related differences in thinking).

- Most development research has been conducted in *WEIRD cultures* (Western, Educated, Industrialized, Rich, Democratic), requiring scientists to be cautious in making generalizations about developmental function.
- *Individual differences* in cognitive function exist both between children and within the same child for different tasks.

The Adaptive Value of Cognitive Immaturity

- Some aspects of infants' and young children's immature cognition may be adaptive in their own right and should not viewed as handicaps that must be overcome.
- Young children tend to overestimate their abilities, which can be attributed in part to *wishful thinking*, in which children fail to differentiate between their wishes and their expectations.

Ask Yourself . . .

1. What is *cognition*? What does it mean to study the *developmental function* of cognition?
2. What are *WEIRD cultures*, and how does science's reliance on research from such cultures affect our views of the universality of cognitive development?
3. What is the bidirectional relationship between structure and function during development?
4. What is meant by individual differences in cognitive development?
5. What are some examples of cognitive immaturity that may be adaptive?
6. How do children's tendencies to overestimate their abilities relate to the development of self-efficacy?

SEVEN TRUTHS OF COGNITIVE DEVELOPMENT

The field of cognitive development encompasses a broad range of topics. Moreover, cognitive developmentalists can be a contentious lot, disagreeing on the best way to conceptualize how thought changes from infancy to adulthood. Nonetheless, I believe there are some truths that typify the study of cognitive development—actually generalizations that I think most developmentalists believe are true about cognitive development, despite the fact that controversy and differences of opinion about specific aspects of these "truths" exist. In the following sections, I examine seven such truths:

1. Cognitive development proceeds as a result of the dynamic and reciprocal transaction of internal and external factors;
2. Cognitive development is constructed within a social context;
3. Cognitive development involves both stability and plasticity over time;

4. Cognitive development involves changes in the way information is represented;
5. Knowledge, or knowledge base, has a significant influence on how children think;
6. Children develop increasing intentional control over their behavior and cognition; and
7. Cognitive development involves changes in both domain-general and domain-specific abilities.

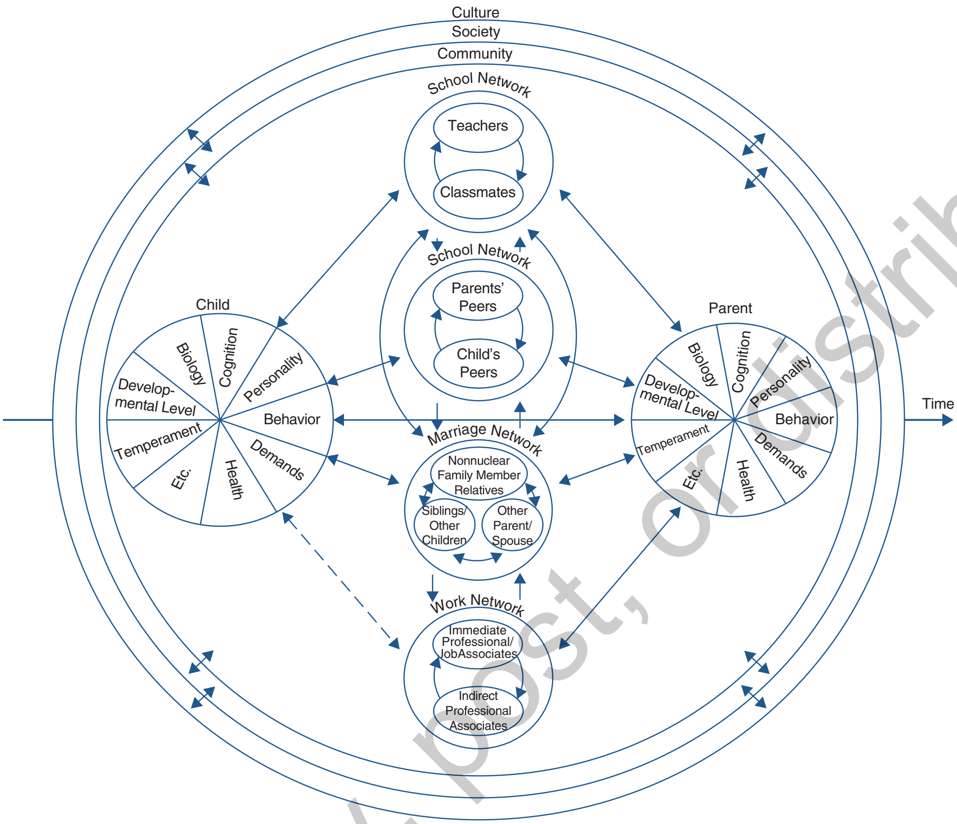
Truth 1: Cognitive Development Proceeds as a Result of the Dynamic and Reciprocal Transaction of Internal and External Factors

This truth follows from the way we define development as the result of the bidirectional relationship between structure and function over time. In essence, this is modern developmental science's answer to the classic nature/nurture issue, which has been the granddaddy of controversies for developmental psychology over its history. How do we explain how biological factors, in particular genetics, interact with environmental factors, especially learning and the broader effects of culture, to produce human beings? At the extremes are two philosophical camps. Proponents of **nativism** hold, essentially, that human intellectual abilities are innate. The opposing philosophical position is **empiricism**, which holds that nature provides only species-general learning mechanisms, with cognition arising as a result of experience. As stated, each of these two extreme positions is clearly wrong. In fact, as far as developmental psychologists are concerned, there is no nature/nurture dichotomy. Biological factors are inseparable from experiential factors, with the two continuously interacting. This makes it impossible to identify any purely biological or purely experiential effects. It is often convenient, however, to speak of biological and experiential factors, and when psychologists do, there is always the implicit assumption of the bidirectional interaction of these factors, as discussed earlier in this chapter (that is, structure ↔ function).

At one level, it is trivial to state that biology and experience interact. There is really no other alternative. It's *how* they interact to yield a particular pattern of development that is significant. For example, one popular view holds that children's genetic constitutions influence how they experience the environment. A sickly and lethargic child seeks and receives less attention from others than a more active, healthy child does, resulting in slower or less advanced levels of cognitive development. A child who processes language easily might be more apt to take advantage of the reading material that surrounds him than will a child whose inherent talents lie in other areas, such as the ability to comprehend spatial relations. Environment is thus seen as very important from this perspective, but one's biology influences which environments are most likely to be experienced and, possibly, how those experiences will be interpreted. These issues are discussed in greater detail in the chapters devoted to individual differences, particularly Chapter 13, in which the heritability of intelligence and the role of experience in individual differences in intelligence is explored.

During the past decades, I have noticed two shifts in emphasis in the field of cognitive development that at first glance might seem contradictory. The first is a greater emphasis given to the

FIGURE 1.2 ■ A Developmental Contextual Model of Person-Context Interaction.



Source: R. M. Lerner. (1991). Changing organism-context relations as the basic process of development: A developmental contextual perspective. *Developmental Psychology, 27,* 27–32. Copyright © 1991 American Psychological Association. Reprinted with permission.

role of context (including cultural context) in development. The second is a greater acknowledgment of the role of biological factors in development. In a field where nature and nurture have traditionally occupied opposite scientific, philosophical, and often political poles, seeing an increasing emphasis on both seems a contradiction, perhaps reflecting a field composed of mutual antagonists, each taking an extreme perspective to counterbalance the other (much like the U.S. Congress seems to function in recent years). This is not the case, however. The current perspective on the dynamic transaction of nature and nurture is one in which biological and environmental factors not only can peacefully coexist but also are intricately intertwined (Goldhaber, 2012; Gottlieb et al., 2006).

Let me provide one brief illustration of how biology and environment are viewed as separate, interacting components of a larger system. Richard Lerner (1991) has been a proponent of the **developmental contextual model**. The basic contention of this model is that all parts of the organism (such as genes, cells, tissues, and organs), as well as the whole organism itself, interact dynamically with "the contexts within which the organism is embedded" (Lerner, 1991, p. 27). This means that one must always consider the organism and context as a unit and that there are multiple levels of the organism and multiple levels of the context. Figure 1.2 graphically presents the developmental contextual model, showing the many bidirectional influences between children, who are born with biological propensities and dispositions, and the contexts in which they find themselves. Perhaps more than anything else, this figure demonstrates the complexity of development. Of equal importance, however, it demonstrates the interactions that occur between the many levels of life, from genes and hormones to family and culture, and the fact that cultural effects cannot be meaningfully separated from their biological influences, and vice versa. The dynamic nature of development, which results from the interaction of a child at many different levels (genetic, hormonal, physical environment, social environment, self-produced activity, and so on), is a theme that runs through most contemporary theories of development.

Truth 2: Cognitive Development Is Constructed Within a Social Context

As I've presented the developmental contextual model, it should be clear that the social environment plays a central role in determining a child's development. A child's biology interacts with a child's social environment to influence a child's developmental trajectory. However, the social environment is not simply the place, so to speak, where development occurs. The culture in which children grow up also shapes, or constructs, their intellects.

We are a highly social species, and human development can only be properly understood when the influences of social relations and the broader social/cultural environment are considered. Development always occurs within a social context, culturally shaped and historically conditioned, although the specific details of a child's social environment can vary widely. From this perspective, one's culture tells children not only *what* to think but also *how* to think (Gauvain & Perez, 2015; Rogoff, 2003; Vygotsky, 1978).

Sociocultural Perspectives

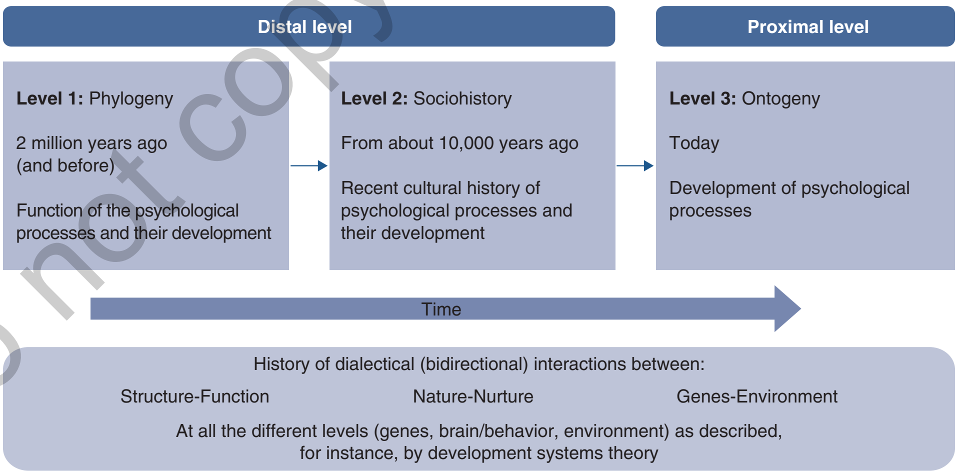
Several **sociocultural perspectives** on cognitive development have emerged over recent decades (Bronfenbrenner & Morris, 2006; Cole, 2006; Rogoff, 2003; see Chapter 3), stemming in large part from the rediscovery of the work of Soviet psychologist Lev Vygotsky (1978). Writing in the 1920s and 1930s, Vygotsky proposed a sociocultural view, emphasizing that development was guided by adults interacting with children, with the cultural context determining largely how, where, and when these interactions would take place. There are many cultural universals, with children around the world being reared in socially structured, language-using groups. Thus, some aspects of development are also universal. But many aspects of culture, such as the available technology and how and when children are expected to learn the survival skills of their society (for example, formal schooling versus no formal schooling), vary greatly. Such differences can have considerable influence on how cognition develops. But how do different cultures construct different experiences for their children to learn, and what consequences does this have for *how* they learn?

Some researchers have noted that children living in traditional societies are more attentive to what adults do and, thus, develop a keener ability to learn through observation than children from schooled societies such as ours (Lancy, 2015; Morelli et al., 2003). These types of cultural experiences affect how children learn. For example, in one study, 6- to 10-year-old children observed a woman creating origami figures and were later asked to make figures of their own (Mejia-Arauz et al., 2005). Some of the children were of traditional Mexican heritage whose mothers had only basic schooling (on average, a seventh-grade education), and others were of Mexican or European background whose mothers had a high school education or more. The children of the more-educated mothers were more likely to request information from the "Origami Lady" than the children with the traditional Mexican heritage. These findings are consistent with the observations that these "traditional" children pay more attention to the actions of the adults and learn more through observation rather than seeking instructions from adults or learning through verbal instructions (see Cole, 2006; Lancy, 2015).

Integrating Approaches

An approach that takes an even longer view of historical influences on development that I think is important for understanding children is *evolutionary theory*, which helps us better understand *why* children and adolescents behave as they do. I believe that a better understanding of the "whys" of development will help us to better understand the "hows" and the "whats" of

FIGURE 1.3 ■ Levels of Analysis of Developmental Phenomena.



Source: Bjorklund, D. F., & Hernández Blasi, C. (2012). *Child and adolescent development: An integrative approach*. Cengage.

development, as well as help us to apply knowledge of child development to everyday problems. Theodosius Dobzhansky (1973) famously said, “Nothing in biology makes sense except in the light of evolution.” Many psychologists make the same argument for psychology, particularly for understanding the development of infants, children, and adolescents. In fact, anthropologist Melvin Konner (2010) has written that nothing in *childhood* makes sense except in the light of evolution. The principles of evolutionary developmental psychology are reviewed in Chapter 2.

Developmental contextual, sociocultural, and evolutionary models of development also represent three levels of analysis (see Figure 1.3). Developmental contextual models examine the development of psychological processes over an individual’s lifetime, beginning before birth. Sociocultural models also look at the immediate causes of behavior but, in addition, take into account the impact of humans’ 10,000-year cultural history on development. Evolutionary theory takes a truly long view of human history, examining the role that natural selection has played in shaping human development, particularly since the emergence of humans as a species about 2 million years ago. You should view these three approaches not as competing perspectives of development but rather as reflecting three different, but compatible, levels of analyses, each of which is important to properly understand development. Because I believe that all of cognitive development (or at least most of it) can benefit from being examined through the lens of these three perspectives, you will find reference to them throughout the book.

Truth 3: Cognitive Development Involves Both Stability and Plasticity Over Time

Cognitive development is about change over time. Yet, once a level of cognitive competence is established, to what extent will it remain constant? Will a precocious infant become a bright 3-year-old and later a talented adult? Or is it just as likely that a below-average 5-year-old will become an above-average high school student, or a sluggish infant a whiz-kid computer jock? Once patterns have been established, what does it take to change them? Can they be modified by later experience? How plastic, or pliable, is the human intellect?

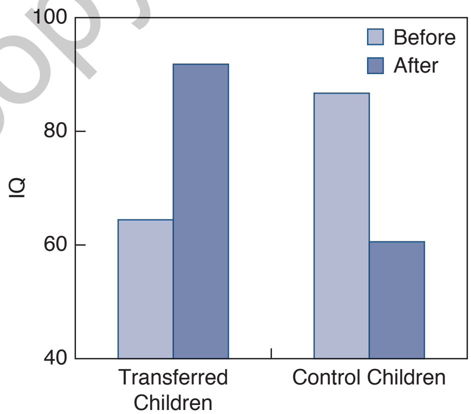
The stability and plasticity of cognition are related. **Stability** refers to the degree to which children maintain their same relative rank order over time in comparison with their peers in some aspect of cognition. Does the high-IQ 3-year-old maintain her position in the intellectual pecking order at age 8 or 18? **Plasticity** concerns the extent to which children can be shaped by experience. More specifically with respect to cognition, once a pattern of cognitive ability is established, to what extent can it be altered? Is our cognitive system highly flexible, capable of being bent and re-bent, or, once a cognitive pattern has been forged, is it relatively resistant to change?

For the better part of the 20th century, psychologists believed that individual differences in intelligence, for example, were relatively stable over time and not likely to be strongly modified by subsequent environments. These views were held both by people who believed that such differences were mainly inherited and by those who believed such differences were mainly a function of environment, but for different reasons. People on the “nature” side assumed that intelligence was primarily an expression of one’s genes and that this expression would be constant over one’s lifetime. People on the other side of the fence emphasized the role of early experience in shaping intelligence. Experience was the important component affecting levels of intelligence, with experiences during the early years of life being most critical.

Jerome Kagan (1976) referred to this latter view as the *tape recorder model* of development. Every experience was seen as being recorded for posterity, without the opportunity to rewrite or erase something once it has been recorded. Evidence for this view was found in studies of children reared in nonstimulating institutions (Spitz, 1945). Infants receiving little in the way of social or physical stimulation showed signs of intellectual impairment as early as 3 or 4 months of age. Not only did these deleterious effects become exacerbated the longer children remained institutionalized; they were maintained long after children left the institutions (W. Dennis, 1973). The finding of long-term consequences of early experience was consistent with Freudian theory, which held that experiences during the oral and anal stages of development (from birth to about 2 years) have important effects on adult personality.

Evidence for the permanence of the effects of early experience was also found in the nonhuman animal literature. For example, Harry Harlow and his colleagues (1965) demonstrated in a series of classic studies that isolating infant rhesus monkeys from their mothers (and other monkeys) adversely affected their later social and sexual behaviors. Without steady interaction with other monkeys during infancy, young monkeys grew up lacking many of the social skills that facilitate important adaptive exchanges, such as mating, cooperation with others, and play. Furthermore, their maladaptive behaviors apparently remained stable over the life of the animals.

FIGURE 1.4 ■ Average IQ Scores Before Placement and 2.5 Years After Completion of Program for Children in the Experimental and Control Groups.



Source: Adapted from data presented in Skeels, H. M. (1966). Adult status of children with contrasting early life experiences. *Monographs of the Society for Research in Child Development*, *31*(Serial No. 105).

Exceptions were found, however, and many began to believe that these exceptions were actually the rule. In one classic study, for instance, infants believed to be intellectually impaired were moved from their overcrowded and understaffed orphanage to an institution for adults with intellectual impairment (Skeels, 1966). There they received lavish attention by women residents, and within the course of several years, these children demonstrated normal levels of intelligence. Figure 1.4 shows the average IQs of these children both before they were placed in the institution for the intellectually impaired and approximately 2.5 years later. Also shown are the IQ scores of "control" children, who remained in the same orphanage the experimental children were removed from and who were tested about 4 years later. As you can see, the transferred children showed a substantial increase in IQ (27.5 points), whereas the control children showed a comparable decline (26.2 points). More recent research on the reversibility of intellectual impairment as a result of institutionalization is presented in Chapter 13. In other work, isolated monkeys were placed in therapy sessions with younger, immature monkeys on a daily basis over a 6-month period. By the end of therapy, these isolates were behaving in a reasonably normal fashion and became integrated into a laboratory monkey troop (Suomi & Harlow, 1972). Each of these studies demonstrates plasticity by a young organism and resilience concerning the negative effects of early environments.

Kagan (1976) proposed that one reason to expect resilience is that development does not proceed as a tape recorder. Rather, development is transformational, with relatively drastic changes occurring between adjacent stages, or phases. During these times, the "tapes" are changed. Alternatively, methods of representing and interpreting the world change so that the codes of the earlier tapes may be "lost" to the child. The tapes of our infancy might still reside in our heads, but we've lost the ability to play them or, maybe, the ability to understand the code in which they were written. In this view, plasticity should be the rule rather than the exception, especially for the experiences of infancy and early childhood.

One important thing to remember here is that, yes, stimulation and experience are important in the early years of life, but so is later experience. Although early intellectual stimulation is important to get children off to a good start, later experiences are necessary to maintain that positive beginning. And although most children who start life in nonstimulating circumstances remain there, enhancements in intellectual skills are apt to occur for such children if their environments change for the better. This does not mean that there is infinite plasticity in cognitive development; it means merely that early experience is not necessarily destiny (just as biology is not) and that change is as much a characteristic of human cognition as is stability.

Before we move on, let us consider a final question relating to the reversibility of deleterious effects of early experience: At what age is plasticity lost? Unfortunately, we are not able to answer this question. We do know from nonhuman animal research that plasticity is reduced with age and that we are most malleable as infants (see Chapter 2). Human development has been proposed to be highly *canalized* during the first 18 or 24 months of life, meaning that all children follow the species-typical path "under a wide range of diverse environments and exhibit strong self-righting tendencies following exposure to severely atypical environments" (McCall, 1981, p. 5). In other words, although early maladaptive environments might adversely affect infants, there is a strong tendency to return to a course of normalcy given an appropriate environment. This plasticity is progressively reduced later in life, beginning as early as 18 or 24 months of age.

Truth 4: Cognitive Development Involves Changes in the Way Information Is Represented

One key issue that all theories of cognitive development must address concerns age differences in how children represent experience. Most psychologists believe that there is more than one way to represent a thing, and children of different ages seem to use different ways to represent their worlds. Adults, as well, use a variety of techniques to represent knowledge. While providing directions to your house to someone over the phone, for instance, you must convey the route to your home verbally, through a language code. But how is it represented in your head? What is the nature of the **representation**—that is, the mental encoding of information? You might think of the route you take by generating visual images of the buildings and landmarks you pass and then convert those into words. Or perhaps you sketch a map and then transform it into words that can be understood by your listener. What the person on the other end of the phone must do is encode the information. At one level, your friend might attend only to the sounds of the words you speak, encoding the acoustic properties of your utterances. If she does, she will probably be late for dinner. More likely, she will attend to the semantic, or meaning, features of the words. Once a basic meaning has been derived, however, she might convert the message to a mental (or perhaps a physical) map, realizing that she will be better able to find your house if the relevant information is in the form of a visual image. (Or she may just put your address into Google Maps and have Siri give her directions as she drives.)

How children represent knowledge and encode events in their world changes developmentally. Traditional theories have proposed that infants and toddlers much younger than 18 months are limited to knowing the world only through raw perception and through their actions on things, with little or no use of symbols. Let me provide an example from the area of memory development. Most people's earliest memories date back to their 4th and possibly their 3rd birthdays. Few people, including 6- and 7-year-old children, are able to recall anything from their earliest years of life, a phenomenon known as *infantile amnesia*. There have been a number of hypotheses about the origins of infantile amnesia, many of which are examined in Chapter 7. One prominent hypothesis is that there are differences in the way experiences are represented between infancy and later in childhood. Infants represent events in terms of sensations and action patterns, whereas preschool and older children (and adults) represent and recall information using language. Support for this position comes from research showing that toddlers with greater verbal abilities at 27 months were more apt to recall an event 12 months later than their less-verbal peers, suggesting that the way information was represented *at the time of the experience* was critical for its later verbal recollection (Simcock & Hayne, 2002; this research will be examined in greater detail in Chapter 7).

Most cognitive developmentalists agree that there are age differences in how children represent their world and that these differences are central to age differences in thinking. Researchers disagree, however, about the nature of these differences. Can children of all ages use all types of symbols, and do they simply use them with different frequencies? Or does representation develop in a stage-like manner, with the more advanced forms of symbol use being unavailable to younger children? I believe most researchers today think that children, beginning in infancy, have multiple ways of representing information, although their ability to mentally represent people, objects, and events increases in sophistication over infancy and childhood. Research and theory pertinent to these and other issues related to changes in representation are central to the study of cognitive development, and they are discussed in the pages ahead.

Truth 5: Knowledge, or Knowledge Base, Has a Significant Influence on How Children Think

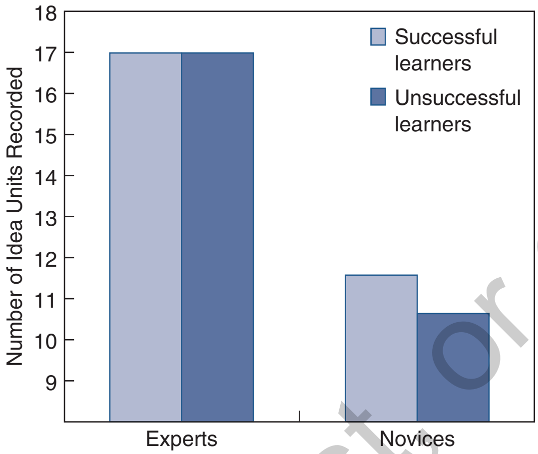
One important component of "support" for children when solving almost any cognitive task is the background knowledge they have about the task. Knowledge is represented in children's minds, and the way that knowledge is represented might change in some qualitative ways with age. But strictly *quantitative* changes in knowledge play a substantial role in cognitive development. Some have proposed that, for most cognitive tasks, knowledge is what differentiates younger from older children. What a child knows affects greatly how a child thinks.

I believe that this latter statement is indisputable. Knowledge cannot be separated from processing, and the amount of knowledge a child possesses, how that knowledge is organized, and its ability to be accessed will largely determine how well a child will solve a problem. From this perspective, children get smarter as they get older because they become more knowledgeable. You will see the effects of background knowledge repeatedly throughout this book—on speed of processing, memory span, and strategies (Chapter 6); event memory (Chapter 7); problem solving (Chapter 8); language acquisition (Chapter 9); gender identification (Chapter 10); reading and mathematics (Chapter 11); and individual differences in cognition, or intelligence (Chapter 12). Increasing knowledge is one of the single most important factors in cognitive development.

However, knowledge itself is not enough. How children organize the knowledge they have is important to how that knowledge will be used, and although the amount of knowledge a child possesses will affect related cognitive processes, such as memory span and speed of processing, these basic-level abilities will also affect how an elaborated knowledge base is used. Again, we must always be cognizant of the interaction between different levels of organization.

Let me provide one classic research example of the effect of children's knowledge base on their cognitive performance in a study by Wolfgang Schneider and his colleagues (1989). In that study, German children in Grades 3, 5, and 7 were classified as either soccer experts or soccer novices and also classified as successful or unsuccessful learners based on IQ tests and their grades in school. The children were then presented with a well-organized narrative text about soccer and were later asked to recall it. Amount remembered was computed as the number of idea units children recalled about the story. The patterns of results with respect to expertise and IQ were similar for the children at each of the three grade levels and are summarized in Figure 1.5 (averaged over grade). As would be expected, memory performance was better for the soccer experts than for the soccer novices. However, the researchers reported no difference in performance between the academically successful learners and the unsuccessful ones. That is, being a good learner (and having a high IQ) did not result in better performance by either the expert

FIGURE 1.5 ■ Number of Idea Units Remembered About a Soccer Story for High- and Low-Aptitude Soccer Experts and Soccer Novices. In this case, being an expert eliminated any effect of academic aptitude (IQ) on performance.



Source: Adapted from data presented in Schneider, W., Körkel, J., & Weinert, F. E. (1989). Domain-specific knowledge and memory performance: A comparison of high-and low-aptitude children. *Journal of Educational Psychology*, *81*, 306–312.

children or the novice children. Having a detailed knowledge of the subject matter was enough to yield high levels of memory performance. Similarly, having an impoverished knowledge of the subject matter was enough to yield low levels of performance, regardless of a child's level of IQ. Although IQ might be related to academic performance, such as reading comprehension, what seems especially important for intelligent performance, at least on the type of tasks assessed by Schenider and his colleagues, is knowledge. Children with substantial knowledge of a subject act smart when dealing with matter from that subject area, independent of their level of IQ.

I think the picture of the role of knowledge—long-term memory representations of events and "facts"—is relatively clear for both developmental function and individual differences. Differences in knowledge base account for much of the variance in performance on many cognitive tasks, with older and more intelligent children typically having more knowledge than do younger and less intelligent children. How much children know about a topic will influence how they process information about that topic and how readily they can acquire new information in that domain. But knowledge is not everything, and the effects of knowledge on task performance will vary with the nature of the task. Moreover, one cannot ignore that there are developmental and individual differences in the processes by which knowledge is acquired.

These processes, and how they interact with the knowledge that a child possesses, must also be understood to get the full picture of cognitive development.

Truth 6: Children Develop Increasing Intentional Control Over Their Behavior and Cognition

Much cognitive developmental (and educational) research is concerned with how children solve problems. And much of what interests cognitive developmental psychologists is how children go about finding solutions to complex problems that might have multiple paths to a solution. For example, how do children solve a puzzle, how do they go about remembering a grocery list, or how do they study for a history exam? Problem solving begins in infancy, but the problems children face, and their solutions, become more complicated with age.

One central concern of cognitive developmentalists has been the degree to which children of different ages can intentionally guide their problem solving. Much research on this topic has addressed the use of strategies. **Strategies** are usually defined as deliberate, goal-directed mental operations aimed at solving a problem (Harnishfeger & Bjorklund, 1990a; Roebers, 2014). We use strategies intentionally to help us achieve a specified goal. Strategies can be seen in the behavior of infants. Six-month-olds alter how hard they swing at mobiles over their cribs to yield slightly different movements from the inanimate objects. Eighteen-month-old toddlers will deliberately stack boxes one on top of another so that they can reach the kitchen shelf and the chocolate chip cookies. These strategies are no less willful than the rhyming mnemonic the sixth grader uses to remember how many days are in each month or the plan the 15-year-old uses as he plays all his trump cards first in a game of bridge. Yet strategies do change with development, and children seem increasingly able to carry out successful strategies as they grow older. So, one key research question in cognitive development concerns changes in the strategies children use and the situations in which they use them.

Although children around the world increasingly display goal-directed problem-solving behavior, this is especially evident for children from technologically advanced societies in which formal schooling is necessary to become a successful adult. Much of what children learn in school can be acquired only (or best) by deliberate study. This contrasts with how children in cultures without formal schooling often learn complicated tasks. In all cultures, much of what children learn about their world they acquire incidentally, without specific intention and, sometimes, even without specific awareness. This type of learning and development is important also, and recent research, particularly in the area of memory development, has recognized this (see Chapters 6 and 7).

Becoming a strategic learner involves learning to regulate one's thought and behavior. This involves a set of basic-level cognitive abilities, referred to as executive function. **Executive function** refers to the processes involved in regulating attention and in determining what to do with information just gathered or retrieved from long-term memory. It plays a central role in planning and behaving flexibly, particularly when dealing with novel information. Among the basic cognitive abilities that comprise executive function are (a) *working memory* (or *updating*)—the structures and processes used for temporarily storing and manipulating information; (b) *inhibiting responding and resisting interference*; and (c) *cognitive flexibility*, the ability to switch between different sets of rules or different tasks. Thus, becoming a "self-directed thinker" (see Chapter 6) involves an understanding of the development of both lower-level cognitive processes (for example, executive function) and higher-level cognitive processes (for example, strategies).

Truth 7: Cognitive Development Involves Changes in Both Domain-General and Domain-Specific Abilities

Theories that postulate cognitive development results from increases in **domain-general abilities** assume that at any point in time, a child's thinking is influenced by a single set of factors, with these factors affecting all aspects of cognition. In contrast to domain-general accounts of cognitive development are theories that postulate that development unfolds as the result of changes in **domain-specific abilities**. This position hypothesizes a certain degree of **modularity** in brain functions, meaning that certain areas of the brain are dedicated to performing specific cognitive tasks (such as processing language). According to these theories, knowing a child's ability for one aspect of cognition might tell us nothing about their level of cognitive ability for other aspects of thinking because different cognitive domains are controlled by different mind/brain functions. At the extreme, domain-specific theories propose that different areas of the brain affect different aspects of cognition, with these areas being unaffected by what goes on in other areas of the brain.

Robbie Case (1992) put the controversy between domain-general and domain-specific theorists succinctly: "Is the mind better thought of as a general, all-purpose computing device, whose particular forte is general problem solving? Or is it better thought of as a modular device, each of whose modules has evolved to serve a unique biological function that it performs in its own unique and specialized way?" (p. 3). As we'll see in Chapters 5 and 6, the predominant theories of cognitive development throughout the 20th century were domain-general ones. Moreover, when talking of individual differences in intelligence, such as those measured by IQ tests, those differences have usually been thought of as being domain-general in nature (see Chapters 12 and 13). Domain-specific theories arose primarily because of the failure of the domain-general theories to account for the unevenness of cognitive function that is frequently observed in development.

Modularity implies inflexibility, in that the individual is constrained by biology to process certain information in certain ways. This can be good, increasing the likelihood that complex information will be properly processed and understood. In discussing the benefits of constraints for infants, Annette Karmiloff-Smith (1992) stated, "They enable the infant to accept as input only those data which it is initially able to compute in specific ways. The domain specificity of processing provides the infant with a limited yet organized (nonchaotic) system from the outset" (pp. 11–13). But the hallmark of human cognition is flexibility. Our species has come to dominate the globe, for better or worse, because we are able to solve problems that biology could not have imagined and have developed technological systems that expand our intellectual powers (such as writing, mathematics, and computers). Such cognition could not be achieved by a totally encapsulated mind/brain, and of course, no serious domain-specific theorist proposes this degree of modularity. What we must keep in mind is the certainty that both domain-general and domain-specific abilities exist, and we must be cautious of claims that postulate otherwise.

SECTION REVIEW

Seven Truths of Cognitive Development

Truth 1: Cognitive development proceeds as a result of the dynamic and reciprocal transaction of internal and external factors.

- *Nativism* (a belief that all intellectual abilities are innate) and *empiricism* (a belief that all intellectual abilities are a result of experience) have been rejected as adequate explanations for cognitive development.
- Biological and environmental factors are seen as interacting in bidirectional relationships, with children playing critical roles in their own development, as reflected by *developmental contextual models*.

Truth 2: Cognitive development is constructed within a social context.

- Contemporary theorists view the social environment as being particularly important for cognitive development, as reflected by *sociocultural perspectives*.
- Some theorists further argue that developmental contextual and sociocultural models of development should be integrated with evolutionary theory to produce a coherent understanding of psychological development.

Truth 3: Cognitive development involves both stability and plasticity over time.

- *Stability* refers to the degree to which children maintain their same rank order relative to their peers over time.
- *Plasticity* refers to the extent to which individuals can modify their behavior and cognition as a result of experience.
- Although for most of the 20th century it was believed that intelligence is relatively stable over time and that experiences later in life cannot greatly affect patterns of intelligence established earlier, more recent research suggests that human intelligence can be substantially modified under certain circumstances.

Truth 4: Cognitive development involves changes in the way information is represented.

- Most researchers today believe that children, beginning in infancy, have multiple ways of representing information, although their ability to mentally represent people, objects, and events increases in sophistication over infancy and childhood.

Truth 5: Knowledge, or *knowledge base*, has a significant influence on how children think.

- Differences in knowledge base account for much of the variance in performance on many cognitive tasks, with older and more intelligent children typically having more knowledge than do younger and less intelligent children.

Truth 6: Children develop increasing intentional control over their behavior and cognition.

- *Strategies* are deliberate, goal-directed mental operations aimed at solving a problem.

- Strategies are especially important for children from technologically advanced societies in which formal schooling is necessary to become a successful adult.
- Strategic cognition is influenced by a host of factors, including a child's levels of *executive function*, referring to processes involved in regulating attention and in determining what to do with information just gathered or retrieved from long-term memory.

Truth 7: Cognitive development involves changes in both domain-general and domain-specific abilities.

- Most traditional approaches to cognitive development have posited *domain-general abilities*.
- Recent research has shown that many aspects of cognition and its development are *domain-specific* in nature, with some forms of cognition being *modular*.

Ask Yourself . . .

1. What is meant by an integrative approach to development, and what are the three levels of analysis proposed in this textbook?
2. Why is an integrative approach to development important?
3. What does stability in cognitive development refer to? How is this related to plasticity in cognitive development?
4. What do cognitive psychologists mean when they talk about representations?
5. What is strategic cognition, and what factors are important in its development?
6. What is modularity? How does it relate to domain-specific and domain-general abilities?

GOALS OF COGNITIVE DEVELOPMENTALISTS

Although I believe the topics discussed in the previous section reflect the major issues in the study of cognitive development, what underlies all of these issues, as I mentioned in the opening pages of this chapter, is a search for the mechanisms responsible for change. We can observe changes in how children represent their world and see evidence of enhanced intentional, goal-directed behavior with age, but as scientists, we very much want to know the causes of these changes, and much of the research in the remainder of this book addresses this issue. Thus, description of change is not enough, although it is a necessary start.

Another goal for many cognitive developmentalists is to produce research that can be applied to real-world contexts. For example, issues about the stability and plasticity of intelligence have direct applications to the remediation of intellectual impairment and to some learning disabilities. Understanding how children learn to use strategies of arithmetic, memory, and reading, for example, is directly pertinent to children's acquisition of modern culture's most important technological skills (see Chapter 11). Research on factors that influence children's recollection of experienced or witnessed events has immediate relevance to the courtroom, where children have increasingly been called to testify (see Chapter 7). Understanding the typical development of both basic (and unconscious) cognitive processes and forms of higher-order (and conscious) cognition provides insight into the causes of some learning disabilities, whether in math and reading (see Chapter 11) or, perhaps, as a result of attention deficit hyperactivity disorder (ADHD) (see Chapter 6). And although extensions to the schoolhouse or clinic may be the most obvious applications of cognitive development research and theory, I believe perhaps the greatest application is to an appreciation of children in general, particularly when they are your own.

KEY TERMS

bidirectionality of structure and function 5
development (or ontogeny) 4
developmental contextual model 15
developmental function 6
domain-general abilities 24
domain-specific abilities 24
empiricism 13
executive function 23
function 5
individual differences 6
modularity 24
nativism 13
plasticity 17
representation 20
self-efficacy 10
sociocultural perspectives 15
stability 17
strategies 23
structure 4
WEIRD cultures 6
wishful thinking 11